Relative Age and Maturation Selection Biases in Academy Football

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This study examined the simultaneous effects of relative age and biological maturity status upon player selection in an English professional soccer academy. 202 players from the U9 to U16 age groups, over an eight-year period (total of 566 observations), had their relative age (birth quarter) and biological maturity (categorised as late, on-time or early maturing based upon the Khamis-Roche method of percentage of predicted adult height at time of observation) recorded. Players born in the first birth quarter of the year (54.8%) were over represented across all age groups. A selection bias towards players advanced in maturity status for chronological age emerged in U12 players and increased with age; 0% of players in the U15 and U16 age group were categorised as late maturing. A clear maturity selection bias for early maturing players was, however, only apparent when the least conservative criterion for estimating maturity status was applied (53.8% early and 1.9% late maturing in the U16 age group). Professional football academies need to recognise relative age and maturation as independent constructs that exist and operate independently. Thus, separate strategies should perhaps be designed to address the respective selection biases, to better identify, retain and develop players.

Keywords: soccer, puberty, talent identification, development, percentage adult height

Introduction

The development of talented soccer players is the primary objective of professional soccer academies and is associated with competitive and financial gains (le Gall, Carling, Williams, & Reilly, 2010). In England, players can be recruited into professional academies from eight years of age. Recruited players benefit from exposure to elite level coaching, sports science and medical support, training equipment and facilities, and competition (Johnson, Farooq, & Whiteley, 2017; Meylan, Cronin, Oliver, & Hughes, 2010; Vaeyens et al., 2006). Players who are initially selected for entry into the academy systems may also have a greater likelihood of achieving professional status in their sport than those excluded (Cumming, Lloyd, Oliver, Eisennnann, & Malina, 2017a). The process of identifying those players with the greatest potential to succeed at the adult level is challenging and necessitates the consideration of technical, tactical, physical, functional, psychological and cultural factors (Reilly, Williams, Nevill, & Franks, 2000; Vaeyens et al., 2006).

Two non-modifiable factors that have been shown to impact player selection and performance in academy soccer are relative age and biological maturation (Meylan et al., 2010; Sierra-Diaz, Gonzalez-Villora, Pastor-Vicedo, & Serra-Olivares, 2017). Relative age refers to a player's chronological age with respect to their competitive cohort and is determined by date of birth and the competition age-group cut-off date. A player born at the beginning of the competitive year (September 1st in English soccer) has a relative age advantage of almost one year relative to players born at the end of the competitive year (31st August). Greater relative age is believed to afford a performance advantage in experience (i.e., more time spent engaged in skill based activities such as soccer) and greater physical, neural, motor, and/or psychosocial maturity (Helsen, Hodges, Kel, & Starkes, 2000; Helsen, Van Winckel,

& Williams, 2005; Simmons & Paul, 2001; Ward & Williams, 2003; Wattie, Cobley, & Baker, 2008). Therefore, relatively older players are more likely to be identified as talented and are, thus, recruited into academies and provided with more support and investment in their development (Delorme, Boiche, & Raspaud, 2010). The relative age effect (RAE), whereby a disproportionate number of players are born early within the competitive year, is well documented in soccer and can be observed in children as young as six to eight years of age (Helsen, Starkes, & Van Winckel, 1998; Musch & Grondin, 2001; Sierra-Diaz et al., 2017). The RAE is marked in academy soccer and appears to remain consistent throughout childhood and adolescence (Barnsley, Thompson, & Legault, 1992; Baxter-Jones, 1995; Helsen, Van Winckel, & Williams, 2005; Votteler & Höner, 2014). While the RAE can still be observed in adult players, the magnitude of the bias is often attenuated (Mujika et al., 2009).

Biological maturation refers to progress towards the adult state, which varies with each biological system, and can be viewed in terms of status, timing and tempo (Malina, Rogol, Cumming, Silva, & Figueiredo, 2015). Maturity status refers to the specific stage of maturation at the time of observation (e.g., skeletal age, stage of pubic hair development), while maturity timing refers to the age at which specific maturational events occur (e.g., age at peak height velocity,). Tempo refers to the rate at which maturation in a specific system progresses and is more difficult to assess (Malina, Bouchard, & Bar-Or, 2004). Of relevance to the current discussion, youth of the same chronological age (CA) can vary considerably in maturity status. Academy soccer players of the same CA can vary by as much as five to six years in skeletal age (Johnson, 2015).

Individual differences in biological maturity status have been shown to directly and indirectly influence player performance and selection in youth football (Cumming et al., 2017a). Players advanced in maturity status for their age are more likely to be selected and recruited into professional academies. Consequently, they are exposed to greater challenge and gain greater access to superior training facilities and coaching and sports science/medicine support (Cumming et al., 2017a; Bloom & Sosniak, 1985). The bias emerges about 11 to 12 years and generally coincides with the onset of puberty (Johnson et al., 2017). The bias is most prevalent in the spine positions (i.e., central defenders, midfielders, and forwards) and increases with age and competitive level (Figueiredo, Goncalves, Coelho-e-Silva, & Malina, 2009; Johnson et al., 2017; Malina et al., 2015; Meylan et al., 2010; Sherar, Baxter-Jones, Faulkner, & Russell, 2007). Players advanced in maturity status for age are, on average, taller and heavier than later maturing peers from 9 years on (Cumming et al., 2017a). The athletic advantages associated with advanced maturation (i.e., greater size, strength, speed, power) are reasonably well documented among youth soccer players (Meylan et al., 2010).

It is often assumed that players born early in the competitive year benefit from being physically more mature than their peers. An older CA does not, however, imply more advanced maturity status. Whereas relative age is a function of birthdate and competition cut off dates, biological maturity status is largely a result of genetic inheritance (Malina, 2014). It is entirely possible for a player born early in the competitive year to be later in maturation and possess little or no advantage in terms of size and/or athleticism. Conversely, a player born late in the competitive year can be advanced in maturity status compared to peers and as such experience no discernible disadvantage. By inference, relative age and maturity status and associated biases should be considered as independent constructs/processes (Cumming et al., 2017a). Whereas the RAE is present from early childhood, maturity-related biases do not emerge among youth soccer players until early adolescence and increases with CA; note, however, the maturity biases are influenced by method of maturity status assessment (Malina, 2011; Malina, Coelho-e-Silva, & Figueiredo, 2013; Malina et al., 2015; 2018). A recent study of elite soccer players from two professional academies showed the RAE was relatively constant from U9 through U17 age groups; however, selection bias for advanced skeletal maturity status emerged at 11-12 years of age and increased about 20-fold from U9 to U17 players (Johnson et al., 2017).

Whereas relatively older age and advanced maturity status have been shown to influence performance and selection in academy football, some evidence suggests that younger and/or later maturing players, if retained within the academy systems, hold the greatest potential for success as adults (Gibbs, Jarvis and Dufur, 2011: Cumming et al., 2017a). Referred to as the 'underdog hypothesis', this contention holds that younger and/or later maturing players must possess superior technical/tactical and/or psychological attributes in order to remain competitive within their cohort (Malina et al., 2015; Zuber, Zibung and Conzelmann, 2016; Cumming et al., 2018). While this may not be enough to make them the best player in childhood and adolescence, these advantages will emerge in late adolescence and young adulthood when age and maturity-associated variation in size and athleticism are attenuated or, in some case reversed (Cumming et al., 2018). In support of this contention, later maturing academy players from England and Switzerland demonstrated superior psychological and technical/tactical profiles than their early maturing peers (Cumming et al., 2018; Zuber, Zibung and Conzelmann, 2016). As such, football academies maybe excluding and/or overlooking players with potential for success in favour of those who are the most able at the time of assessment (Cumming et al., 2018).

The purpose of this study is to examine the simultaneous effects of relative age and biological maturity status upon player selection in the English professional soccer academy of Southampton Football Club. The Club has been identified as the most profitable youth soccer academy in Europe and as an "outstanding example of how youth training can constitute key competitive advantage both sportingly and economically" (CIES, 2015). In 2015, fees received by Southampton represented almost 40% of the total incomes generated by Premier League clubs through the transfer of club-trained players (CIES, 2015). Southampton's academy also has an excellent reputation for effectively nurturing talented yet late developing players (Lansley, 2016). It was, therefore, of interest to address selection biases within this prominent and leading academy.

Method

Participants

Participants included academy players registered at the Southampton Football Club. A total of 202 participants spanning U9 through U16 competitive age groups were assessed once annually, between September and December, over a period of eight years (2010-2017). Some participants were measured in successive age categories as they moved through the system. The sample consisted of predominantly European Caucasians.

Ethics and consent

Through the process of registering with Southampton Football Club academy, individual players and their parents/guardians consent to the routine collection of data and the potential use of this data for research purposes. All measurements of height and weight were taken on a voluntary basis and participants had the right not to be assessed. The ethics committee at the University of Bath approved this research study and the right to use the retrospective data.

Relative age

Relative age was established from the birth date of each player and the cut-off date for the respective year group (August 31st). The selection year for youth football spans September 1st through August 31st, and relative age was recorded as birth quarter. As such, birth quarters were defined as quarter one (oldest-BQ1): players born between September 1st through November 30th; birth quarter 2: those born between December 1st through to end of February; birth quarter 3: those born from March 1st through to May 31st; and finally birth quarter 4 (youngest-BQ4): players born between June 1st through to August 31st.

To create a more developmentally sensitive measure of relative age, this construct was also expressed as a decimal, using the difference between player birthdate and the cut-off date of the selection year, divided by the number of days within the year (Cumming et al., 2018). Accordingly, relative age is expressed as a value between 0 and 0.99, with the lowest and highest values representing the youngest and oldest athletes respectively, for the statistical analysis.

Biological maturity status

Percentage of predicted mature height attained at the time of observation (one measurement between September and December) was used as the estimate of biological maturity status (Roche, Tyleshevski, & Rogers, 1983). It is assumed that among children of the same age, those closer to their predicted adult height are more advanced in maturation compared to those further removed from predicted adult height. The Khamis-Roche method (Khamis & Roche, 1994) for the prediction of adult height was used; the protocol requires current age, height and weight of the youngster and mid-parent height (i.e., mean of the heights of biological parents). Academy sports science staff using standardized procedures measured height and weight. Parental heights were self-reported and adjusted for overestimation (Epstein, Valoski, Kalarchian, & McCurley, 1995). The median error bound between actual and predicted adult height using the Khamis-Roche method is 2.2 cm in males, from 4 to 17.5 years of age (Khamis & Roche, 1994).

Estimated biological maturity status was expressed as a z-score, using the percentage of adult stature attained at observation and age-specific means and standard deviations for boys followed longitudinally in the Berkeley Growth Study (Bayer & Bailey, 1959). The z-scores were used to classify players as late, on-time or early maturity as in other studies of youth athletes (Cumming, Standage, Gillison, Dompier, & Malina, 2009; Figueiredo et al., 2009; Gillison, Cumming, Standage, Barnaby, & Katzmarzyk, 2017; Johnson et al., 2017; Malina, Cumming, Morano, Barron, & Miller, 2005; Drenowatz et al., 2013). For the primary analysis, a z-score of -1 to +1 defined average maturity status; a z-score greater than +1 defined early status and a z-score below -1 defined late status. Recognising that the traditional methods for categorising early and late maturation do not differentiate between individuals who differ markedly in maturity (e.g., z scores of +.99 and -.99 are both deemed on-time) and may be less sensitive to subtle biases, a second and less conservative set of criteria was also considered. For this secondary analysis, a z-score of -0.5 to +0.5 (as currently employed in the Premier League Player Management Application) was used to define defined average maturity status; a z-score greater than +0.5 defined early status while a z-score below -0.5 defined late status (Drenowatz et al., 2013).

Classifications of maturity status based on z-scores for percentage of adult height at the time of observation and differences between skeletal and CA's (SA minus

CA) have been compared in American football players 9-14 years (Malina, Dompier, Powell, Barron, & Moore, 2007) and Portuguese soccer players 11-14 years (Malina, Coelho-e-Silva, Figueiredo, Carling, & Beunen, 2012). Although the concordance of classifications was significant and generally moderate, the protocol has demonstrated concurrent validity in studies of British, North American, and Portuguese youth (Cumming, Battista, Standage, Ewing, & Malina, 2006; Malina et al., 2012; Rodrigues et al., 2010; Smart et al., 2012).

Statistical methods

The data were analysed using SPSS version 22.0. Descriptive statistics were used to examine variance in relative age, size, and maturity status across the competitive age groups. Ordinal regressions with a generalised estimating equation were used to examine the degree to which relative age and maturity status affected player selection across age groups (Johnson et al., 2017). An exchangeable correlation structure was applied to account for correlations among repeated measures of relative age and maturation within players and improve the estimation efficiency of the models. Odds ratios and 95% confidence intervals were used to portray the relative likelihood of group members being present compared to the reference population (under 9 age group). To assess differences between observed and expected birthdate distributions (even distribution throughout any 12 month period), a Kolmogorov-Smirnov one-sample test was used.

Results

Descriptive statistics (means and standard deviations) for the variables of interest are summarized by competitive age group in Table 1. As expected, height, weight, BMI and percentage of predicted adult stature attained at the time of observation increase, on average, with CA. Relative age, expressed as a decimal of the selection year, is, on average, above the expected population value 0.5 years in all age groups, and indicates a greater representation of players born early within a competitive age group. Estimated maturity status, expressed as z-scores of percentage of predicted adult height attained at the time of observation, is, on average, negative but approximates zero among U9 through to U11 players. The mean maturity status z-score is positive among U12 players and generally increases with CA.

****Table 1 near here****

When expressed by birth quarters (BQ), 54.8% of all players were born in BQ1 of the selection year (September- November); corresponding percentages of players born in the other birth quarters were 17.3% (BQ2), 15.2% (BQ3) and 12.7% (BQ4). The RAE is present in every group from U9 through U16 (Figure 1), indicating the disproportionate number of the youth players in each competitive age group born early in the selection year (Kolmogorov-Smirnov test, D [566]=0.258, p=0.001).

****Figure 1 near here****

Using a z-score of ±1.0 for percentage of predicted adult height attained at the time of observation, the overwhelming majority of the players (84.8%) are classified as 'on-time' or average in maturity status, while early and late maturing players comprise 9.5% and 5.7% of the sample, respectively. The relative distributions of late, on time and early maturing players by competitive age group are shown in Figure 2. The percentage of early maturing players peaks in the U13 age group at 16.3% and declines to 5.8% in the U16 group. The percentage of late maturing players peaks at 15.1% in the U9 age group and declines steadily with age. No late maturing players are represented in the U15 and U16 age groups.

Using the less conservative criterion to estimate maturity status (z-score of ±0.5 for percentage of predicted adult height attained at the time of observation), the distributions of players by estimated maturity status within each competitive age group are shown in Figure 3. With the less conservation criterion, 51.2% of the total sample is classified as on-time, 30.4% as early and 18.4% as late maturing. By competitive age groups, the percentage of early maturing players peaks in the U16 age group (53.8%). With the exception of U9 players, the percentage of early maturing players increases with CA. In contrast, the percentage of late maturing players peaks at 33.3% in the U11 age group, and decreases with increasing CA.

****Figure 2 near here****

****Figure 3 near here****

****Table 2 near here****

Results for the ordinal regression analyses are presented in Table 2. The results indicate a small but significant reduction in the RAE beyond the youngest age group. Note, however, the magnitude of the differences, though statistically significant, is small, only a 1% to 2% reduction in likelihood. The magnitude of the differences also does not vary with CA. The regression results for biological maturity status (z-score ±1.0) show significant differences in only U13 and U14 players. In these competitive age groups, advanced maturity status for age is associated with a greater likelihood of representation compared to the youngest age group. The magnitude of the increments varies from 3.2 in U13 players to 2.7 in U14 players.

When the less conservative maturity criterion is applied (z-score ±0.5) (Drenowatz et al., 2013), the results for biological maturity status show a significant difference for all competitive age groups from U12 through U16 compared to U9 players. This effect increased in magnitude with each successive age group, ranging from 2.6 times in U12 to 8.1 times U15 players.

Discussion

The simultaneous effects of relative age and biological maturity status upon player selection and retention in a professional soccer academy were evaluated. Consistent with previous research (Barnsley et al., 1992; Helsen et al., 2005; Musch & Grondin, 2001; Musch & Hay, 1999; Sierra-Diaz et al., 2017), a disproportionate number of academy players (>72%) were born in the first half of the competitive year. The RAE was present and greatest among U9 players, and remained relatively consistent across U10 through U16 players.

In contrast, a distinct selection bias favouring players advanced in maturity status was observed only when a conservative criterion for classification of maturity status was applied (z-scores of ±0.5). Using this criterion, the selection bias emerged in the U12 age group and increased in with age. When the commonly used criterion for classifying players by maturity status was applied (z-scores of ±1.0) (Malina et al., 2005; 2007; Rommers et al., 2019; Cumming et al., 2009), a selection players, bias favouring players advanced in maturity status was noted only among U13 and 14 players, but the magnitude of the bias was comparatively small. The disparate findings observed with the two criteria highlight the need for researchers and practitioners to consider how they define early, on-time and late maturation and the cut-off points adopted and reinforces the need to imply more sensitive measures of maturation. The samples used to develop the adult height prediction equations (Fels Longitudinal Study) and reference values used to convert percentage of predicted adult height into z-scores (Berkeley Growth Study) were developed on children and adolescents of European ancestry (White) from families of middle and upper socioeconomic status from, respectively, Ohio (Roche, 1992) and California (Bayer and Bayley, 1959). In addition, parental heights were reported and not measured.

The conservative criterion suggested limited impact of maturity status upon player selection and retention, while the less conservative criterion suggested otherwise. Criterion that are too conservative (i.e., z-scores of ±1.0) may fail to differentiate between individuals that are markedly different in terms of maturity status, increasing the likelihood for type two errors. Nevertheless, the range of -1.0 to +1.0 for z-scores to define average status was based upon observations with skeletal age. The band of ±1.0 year approximated standard deviations for skeletal age within single year CA groups of boys 11-17 years in the general population (Malina, 2011, Malina et al., 2018) and also allows for error associated with estimates of skeletal age. It should be noted however, that the use of a less conservative criterion (±0.5 z-score) for determining maturity status may serve as a more sensitive strategy for detecting biases, it also may increase the likelihood of type one errors. That said, the increase in the magnitude of the observed bias across the age groups is consistent with previous research (Johnson et al., 2017), suggesting the presence of such a bias.

The results of the current investigation are consistent with studies of youth soccer players which used skeletal age as the indicator of maturity status, i.e., advanced maturity status appeared to act as a positive predictor of persistence, selection and retention in the sport (Johnson et al., 2017; Malina et al., 2015; Carling, Le Gall, & Malina, 2012). It should be noted, however, that the majority of the players in the current investigation, regardless of age group or maturity criterion applied, were considered 'on-time' with percentage of predicted adult height at the time of observation as the indicator of maturity status. Further, the odd ratios associated with the maturity selection bias in the current investigation were notably lower than the equivalent values reported by Johnson et al (2017). Collectively, the findings suggest that while advanced maturity status is associated with an increased likelihood of selection and retention in the current cohort, the magnitude of this bias is comparatively small when considered against other cohorts addressing RAE effects (Johnson et al., 2017).

On the other hand, late maturing players were less likely to be represented with increasing age, regardless of the criterion employed. This was especially noticeable in the oldest age groups, with no late maturing players being represented in U15 and U16 teams. This observation is of particular concern as it in these older groups that the academies must decide whether to offer players a full-time scholarship or release them (Mills, Butt, Maynard, & Harwood, 2012). Further research is required to better understand the nature of this bias and the extent to which talented, yet late maturing players are being excluded from the academy system.

The systematic exclusion of younger and/or later maturing players (Figueiredo et al., 2009; Johnson et al., 2017; Malina et al., 2015) is of particular concern; especially as emerging evidence suggest that late maturing players often possess/and or develop superior technical, tactical, and/or psychological skills. While it has been argued that the greater physical challenges experienced by the late developers better prepares them for success as adults, such arguments only hold if these players are retained within the system. The results from the present study, and previous literature, suggest that this is not the case (Johnson et al., 2017; Malina et al., 2015). Arguments that ‘the cream will always flow to the top’ and that relative age and maturity selection biases are integral parts of what is described as an inefficient, yet effective, model of talent development are flawed in that they fail to recognise that very few younger and/or late developers are retained in the system. Equally, those who are older and or advanced in maturity may not be optimally challenged (Cumming et al., 2017a). Such models are also flawed on the basis that players are selected based on attributes (relative age, body size and maturity status) over which they have no control and which are fully realised in young adulthood (Cumming et al., 2017a). Indeed, such models of talent development are perhaps better described as both inefficient and ineffective; once late maturing and/or relatively younger players are excluded, they receive less training, resources and coaching, thus are unlikely to be able to return to the professional system later (Figueiredo et al., 2009; Musch & Hay, 1999). Reducing selection biases associated with relative age and biological maturity status whilst reinforcing meritocracy in football, is an important component of long-term development of both the players and club.

Results of this study provide a unique insight into the selection and retention practices at a professional soccer academy. Relative age effects were present on entry into the academy system and persisted through the developmental pathway. In contrast, the selection bias favouring youth more advanced in biological maturity emerged among U12 players and increased with age. As small yet inverse relation was observed between maturity status and relative age ($r = -0.14$, $p=0.001$), indicating that older players were less advanced in maturation for their age and sex. Although this finding appears counterintuitive, advanced maturity status may offset some of the disadvantages associated with being younger (less experience, technical/tactical aptitude), enabling these players to remain competitive within their age group. More recently, it was noted that Portuguese soccer players 11 and 13 years of age born late in the year were tended to be advanced in skeletal maturity for their CA (Figueiredo et al., 2019a). Moreover, birth quarter distributions of Portuguese U13 and U15 players did not differ between those no longer involved and those still competing in the sport in young adulthood, and also between players playing regionally and nationally (Figueiredo et al., 2019b).

Collectively, the results of the present study support the contention that relative age, biological maturity status and their respective selection biases operate as independent constructs/processes and should be considered and treated as such among youth players. The presence of RAE from mid-to-late childhood suggests that this phenomenon cannot be attributed to the functional advantages associated with advanced biological maturation, which emerge with the onset of puberty (i.e., 11-12 years of age). Rather, the RAE in childhood is perhaps more likely to reflect age-related variation in a variety of other factors including neuromuscular maturation, behavioural development, experience, training, and perhaps other factors. The evidence would also suggest that strategies designed to address the RAE should focus on such attributes and be introduced from early childhood; whereas strategies to address individual differences in biological maturity would be most effective during early and mid-adolescence. Though potentially interesting, what is lacking in research interpreting the RAE and variation in biological maturation is the interactions between these variables and the adults who train and select youth players, which may perhaps be labelled the "environment of the academy".

Several strategies have been advanced to address RAE and maturity-related selection biases in sport. Use of age-ordered shirt numbers, for example, reduced the selection bias associated with relative age among professional scouts (Mann & van Ginneken, 2017). In a similar vein, a number of professional academies have experimented with 'quarter four trial days', whereby only players born in the fourth quarter of the competitive year are allowed to participate (Hibernian Media, 2016). An "average team age rule", whereby teams may consist of players with a mean within a specific range, has also been advanced as potential solution to the RAE (Andronikos, Elumaro, Westbury, & Martindale, 2016; Lawrence, n.d.).

In an effort to balance maturity-related variation, the Premier League recently trialled the practice of bio-banding whereby players within a specific CA range are grouped by estimated maturity status. As a practice, bio-banding is designed to attenuate and better manage maturity-associated differences in size and function and to expose early and late maturing players to novel and more developmentally appropriate learning experiences (Cumming et al., 2017a). Players have unanimously supported bio-banding (as an adjunct to age group competitions), though reasons for doing so varied with maturity status (Cumming et al., 2017b). Playing up, early maturing, chronologically younger boys described their experiences as more physically and technically challenging, as a better learning experience, and as an opportunity to play with and be mentored by chronologically older yet physically matched peers. Such opportunities may also help early maturing boys develop the same psychological and technical/tactical qualities that appear requisite for the survival of the late maturing players (Cumming et al., 2018; Zuber, Zibung and Conzelmann, 2016). Late maturing, chronologically older players described their experiences as less physically and technically challenging, but appreciated the opportunity to use/demonstrate their physical and technical attributes, and to adopt positions of leadership (Cumming et al., 2017b). Although results of the Premier League bio-banding initiative are promising, further research applying and evaluating the strategy is required.

Several limitations of the current study should be noted. First, the results are specific to a single football academy and may not be generalizable to other clubs, competitive programmes, or countries. Second, the method used to estimate biological maturity status used self-reported adult heights and the height prediction equation and reference values used to derive the z-scores were based on samples of European (White) ancestry in the United States (Ohio and California). Moreover, percentage of predicted adult height at the time of observation may not be directly comparable to studies using more clinically based estimates of biological maturity status, specifically skeletal age or stage of pubertal development (Malina et al., 2004). Spearman rank order correlations between the protocol used in the present study and skeletal age and stage of pubic hair development, though moderate, were higher in soccer players 13-14 years compared to players 11-12 years (Malina et al., 2012).

In summary, selection biases towards players who are born earlier in the competitive year and who are advanced in biological maturation exist in academy football. Relative age effects were present from entry into the academy system and maintained throughout the competitive age range considered, while biological maturity status selection biases were only evident from early adolescence when the less conservative criterion for estimating maturity status was applied. The results were also consistent with the contention RAE and maturity status related selection biases are separate processes and as such should be considered independently. Further research is required to better understand the nature and sources of the selection biases and how they may be used to optimise opportunity for all youth players.

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